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RESEARCH ARTICLE

Association between deep-water scale-worms (Annelida: Polynoidae) and black corals (Cnidaria: Antipatharia) in the Southwestern Atlantic

José Eriberto De Assis[1], José Roberto B. de Souza[2], Manuela M. de Lima[2], Gislaine V. de Lima[2], Ralf T.S. Cordeiro[2], Carlos D. Pérez[3]

[1]*Departamento de Educação, Secretaria Municipal de Educação, Prefeitura Municipal de Bayeux. 50670-420 Bayeux, PB, Brazil.*
[2]*Departamento de Zoologia, Centro de Biociências, Universidade Federal de Pernambuco. 50670-420 Recife, PE, Brazil.*
[3]*Centro Acadêmico de Vitória, Universidade Federal de Pernambuco. 55608-680 Vitória de Santo Antão, PE, Brazil.*
Corresponding author: José Eriberto De Assis (eri.assis@gmail.com)

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ABSTRACT. Polynoid scale-worms have been found living as commensals with deep-water antipatharians (commonly known as black corals) in the Potiguar Basin, off Rio Grande do Norte State, Northeastern Brazil. In this paper two polychaete species and four black corals species are redescribed. *Benhamipolynoe* cf. *antipathicola* and *Parahololepidella* cf. *greeffi*, and the black coral *Stylopathes adinocrada* Opresko, 2006 are recorded for the Southwestern Atlantic. *Benhamipolynoe* cf. *antipathicola* was first described from off New Zealand and the Malay Archipelago, as symbiont with the black coral *Stylopathes tenuispina* (Silberfeld, 1909). It was later reported for the North Atlantic, off Florida, associated with *Stylopathes columnaris* (Duchassaing, 1870). In our study, *B.* cf. *antipathicola* was found in association with the black coral *S. adinocrada*. *Parahololepidella* cf. *greeffi* was first described as a free-living from shallow waters off São Tomé and Cabo Verde Islands, West Africa, and later reported as symbiont with the black coral *Tanacetipathes* cf. *spinescens* in the same location. Our data expand both the geographical distribution and the host range of this species which is reported for the first time as symbiont with *Tanacetipathes barbadensis* (Brook, 1889), *T. tanacetum* (Pourtalès, 1880) and *T. thamnea* (Warner, 1981) in Brazil. The aim of this study is to discuss commensal associations between two species of scale-worm polynoids and black corals found in the Southwestern Atlantic, and also reporting their global distribution. Finally, we provided an updated list of the commensal polynoids and their black coral hosts.

KEY WORDS. Brazil, Hexacorallia, polynoids, South America, symbiosis.

INTRODUCTION

Specialized symbiotic associations involving polychaetes are ubiquitous in all oceans (Britayev and Antokhina 2012). The Polynoidae, also known as polynoids or scale-worms, includes the largest number and the most commonly reported species living as commensals, representing more than 45% of all known reports of symbiont polychaetes (Martin and Britayev 1998, 2018). More than 200 species are involved in about 600 relationships, representing about 25% of all known polynoid species (Britayev et al. 2014, Martin and Britayev 2018, Serpetti et al. 2017).

Polynoids are often found associated with other invertebrates, especially corals, echinoderms, mollusks, and other polychaetes (Pettibone 1991, Martin and Britayev 1998, 2018, Eckelbarger et al. 2005). They may either construct their own refuges on the host's surface or stimulate their hosts to build protective structures around them. Some species may live inside tunnels or gall-like cavities formed by coenenchymal walls of gorgonian or hydrocoral hosts (Martin and Britayev 1998, 2018, Williams and López-González 2005, Wagner et al. 2012).

Cnidarians are known to host abundant and diverse symbiotic fauna, including polychaetes, with records of 281 species of cnidarian hosts involved in 324 relationships with their hosts (Molodtsova et al. 2016). Antipatharia (Cnidaria: Anthozoa) is the least studied group of corals (Cairns 2007), particularly in the South Atlantic (Loiola 2007). Their colonies consist of chitinous skeletons covered with numerous tiny spines. Some families have developed close relationships with certain scale worms, forming tunnels by bending and anastomosing its branches or pinnules, providing ideal refuges (Molodtsova and Budaeva

2007). Black corals are generally slow-growing and long-living organisms, generally found in areas with hard substrates, low light levels and strong currents; with longevity ranging from 12 to 4265 years, in *Antipathes griggi* Opresko, 2009, known formerly as *Antipathes dichotoma* Pallas, 1766, and *Leiopathes* sp., respectively (Molodtsova and Budaeva 2007, Wagner et al. 2012, Brugler et al. 2013). Along with octocorals, antipatharians are habitual hosts not only for polychaetes, but also for a myriad of associated organisms including barnacles, ophiuroids, copepods, crabs, shrimps, anemones, zoanthids, hydroids, crinoids, bryozoans, snails, bivalves, tunicates and fishes (Buhl-Mortensen and Mortensen 2004, Wagner et al. 2012). The aim of this study is to discuss commensal associations between two species of scale-worm polynoids and black corals found in the Southwestern Atlantic. We redescribe and illustrate the specimens found, also reporting their global distribution and providing an updated list of the commensal polynoids and their black coral hosts.

MATERIAL AND METHODS

The specimens of scale-worms and their antipatharian hosts were collected in the Potiguar Basin, Rio Grande do Norte State, Northeastern Brazil (Fig. 1), by trawling during the surveys of the Program for megafauna characterization of the Potiguar Basin (funded by PETROBRAS), on board of the RV Seward Johnson, between 101 and 461 m depth. Specimens were fixed in a 4% formaldehyde-seawater solution, then rinsed with fresh water and preserved in 70% ethanol. The hosts were observed under a Zeiss stereomicroscope.

Polychaete identifications were based on chaetae, aciculae, and elytra observed under an Olympus BX41 compound microscope. Optical microscope Images were obtained with a Leica M205A. We also provide detailed scanning electron microscope (SEM) images of the parapodial structures and elytra. Measurements are given in mm. The polychaete structures were analyzed according to Pettibone (1989, 1991) and Britayev et al. 2014.

Black corals were identified and described following Loiola and Castro (2005) and Opresko (2006), mainly based on pinnule and subpinnule number, order and size, branching pattern, average distance between spines, and subpinnule number per pinnule using a Leica DM 300 compound microscope. Branche microstructures were also illustrated by SEM.

Voucher specimens were deposited in the Museu de Oceanografia Prof. Petrônio Alves Coelho (MOUFPE-CNI), Universidade Federal de Pernambuco, Brazil.

TAXONOMY

An updated list of the polychaetes associated to black corals, including the new records found in our study is presented in Table 1. The symbiotic partnerships found in Potiguar Basin are reported below.

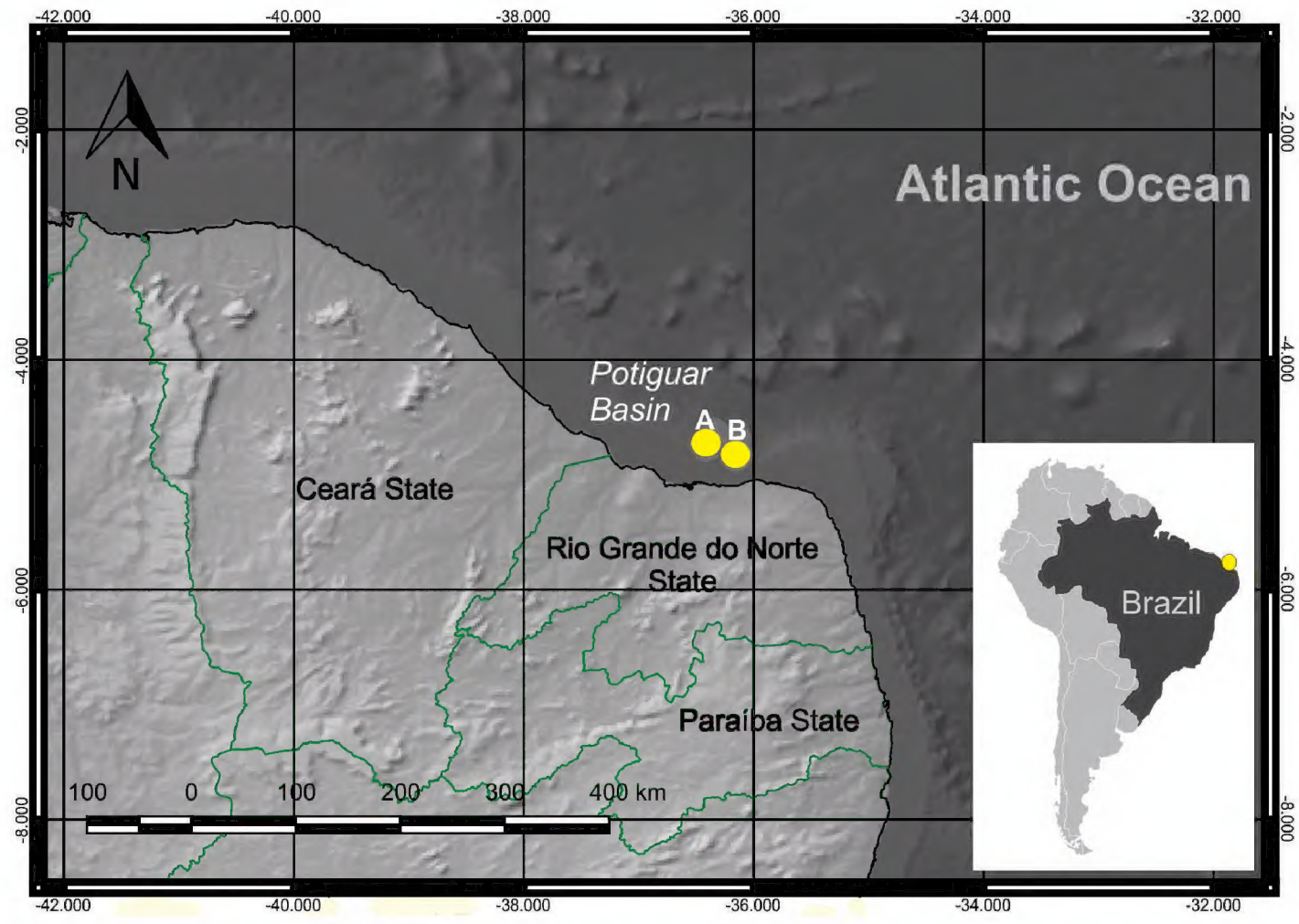


Figure 1. Records of association of scale-worm polynoids and black corals from deep-water in South America, Northeastern Brazil: (A) record of *Benhamypolynoe* cf. *antipathicola,* and its antipatharian hosts *Stylopathes adinocrada* in Potiguar Basin; (B) records of association of *Parahololepidella* cf. *greeffi* and its antipatharian hosts (*Tanacetipathes barbadensis*, *T. tanacetum* and *T. thamnea*) in Potiguar Basin, Brazil.

Table 1. List of known polychaete species associated with antipatharian hosts: 1: Pettibone (1970), 2: Wagner et al. (2012), 3: Britayev et al. (2014), 4: Pettibone (1991), 5: Martin and Britayev (1998), 6: Hanley and Burke (1991), 7: Barnich et al. (2013), 8: Molodtsova and Budaeva (2007), 9: Hartmann-Schröder and Zibrowius (1998), 10: Molodtsova et al. (2016), 11: Glasby (1994), O: Obligatory, F: Facultative.

Symbiont	Host antipatharian	Type of association	References
Polynoidae			
Benhamipolynoe cf. *antipathicola* (Benham, 1927)	Aphanithidae: *Asteriopathes arachniformis* Opresko, 2004	O	8, 10
	Stylopathidae: *Stylopathes tenuispina* Silberfeld, 1909	O	1
	Stylopathes columnaris (Duchassaing, 1870)	O	1, 2
	Stylopathes adinocrada Opresko, 2006, New host	O	This paper
Parahololepidella cf. *greeffi* (Augener, 1918)	Myriopathidae: *Tanacetipathes* cf. *spinescens* (Gray, 1857)	F	3
	Tanacetipathes barbadensis (Brook, 1889), New host	F	This paper
	Tanacetipathes tanacetum (Pourtalès, 1880), New host	F	This paper
	Tanacetipathes thamnea (Wagner, 1981), New host	F	This paper
Antipathypolyeunoa nuttingi Pettibone, 1991	*Tanacetipathes tanacetum* (Pourtalès, 1880)	F	2, 4
Bayerpolynoe floridensis Pettibone, 1991	Stylopathidae: *Stylopathes columnaris* (Duchassaing, 1870)	O	2, 5
Brychionoe karenae Hanley and Burke, 1991	Leiopathidae: *Leiopathes* sp.	O	6
Eunoe purpurea Treadwell, 1936	Schizopathidae: *Bathypathes* cf. *alternata* Brook, 1889	F	7
Neohololepidella antipathicola Hartmann-Schröder & Zibrowius, 1998	Aphanipathidae: *Elatopathes abietina* (Pourtalès, 1874)	F	8, 9
	Distichopathes filix (Pourtalès, 1867)		
Tottonpolynoe symantipatharia Pettibone, 1991	Schizopathidae: *Parantipathes* sp.	F	4
Eunicidae			
Eunice antipathum (Pourtalès, 1867)	Myriopathidae: *Distichopathes filix* (Pourtalès, 1867)	F	8, 9
	Elatopathes abietina (Pourtalès, 1874)		
Eunice kristiani (Hartmann-Schröder & Zibrowius, 1998)	*Anthipates cylindrical* Brook, 1889	F	8
Eunice marianae (Hartmann-Schröder & Zibrowius, 1998)	*Anthipates cylindrical* Brook, 1889	F	8
Syllidae			
Bollandiella antipathicola (Glasby, 1994)	Myriopathidae: *Anthipates* sp.	F	11

Benhamipolynoe cf. *antipaticola* and *Stylopathes adinocrada*

Symbiotic scale-worm

Polynoidae

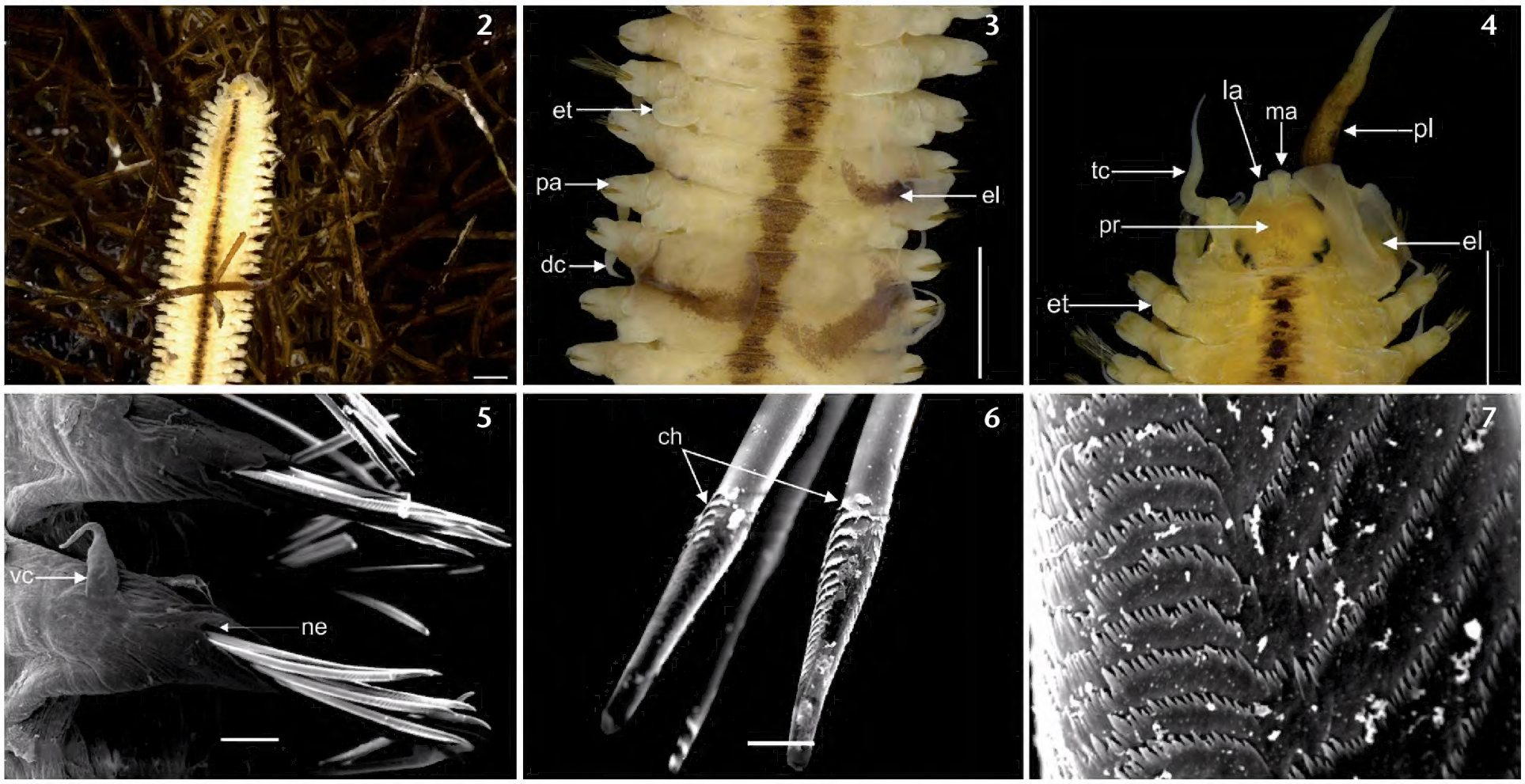
Benhamipolynoe Petttibone, 1970

Benhamipolynoe cf. *antipaticola* (Benham, 1927)

Figs 2–7

Lapidasthenia antipaticola Benham, 1927: 7–182, pl. 1–6.

Description. Body brownish, with continuous middorsal longitudinal reddish-brown band, transverse bands from elytra near parapodial bases. Body dorsoventrally flattened, elongate, slender, with nearly parallel sides, tapering posteriorly, subrectangular in cross-section. Seventeen symmetrical pairs of elytra; elytra colorless, transparent with median crescent-shaped dark pigmentation; on elytrophores of segments 2, 4, 5, 7, alternate segments to 29, 32, and 35; elytra continue to middle body, irregularly distributed, may be asymmetrical, with an elytron and cirrus on same segment, or from one to five cirri in succession (Figs 2–3). Elytra lacking fringes, papillae and tubercles, except for some scattered micro-tubercles. Prostomium bilobed, as wide as long, without cephalic peaks; with three antennae and two short, tapering, smooth palps. Ceratophore of median antenna short, cylindrical, inserted in anterior notch of prostomium; lateral antennae inserted terminally or subterminally on anterior part of prostomium, at the same level or slightly ventral to median antenna (without distinct ceratophores); antennae longer than prostomium, tapered, smooth; two pairs of eyes moderate in size; anterior pair on dorsolateral prostomial width, posterior pair near to posterior border. Tentacular segment anterolateral to prostomium, bearing two pairs of long tentacular cirri, upper pairs much longer than lower pairs; basis of tentacular cirri with aciculum, but lacking chaetae. Buccal segment lacking distinct nuchal fold; supporting first pair of dorsal elytra and long ventral buccal cirri (Fig. 4). Parapodia sub-biramous, with small notopodia on anterodorsal lobe; prechaetal lobe quadrangular or subtriangular, postchaetal short and subtriangular, both with acicula. Notopodia short, conical, achaetous acicular lobe. Neuropodia elongate, with a ventral and dorsal deep incision; with subequal, rounded prechaetal and postchaetal lobes (Fig. 5); with 5–11 neurochaetae, rather stout, smooth or with slight indications of spinous rows and falcate tips (Figs 6–7). Ventral cirri short, subulate, extending slightly beyond neuropodial lobe tips. Dorsal cirri with short cylindrical cirrophores; styles smooth, tapering gradually to filiform tips, extending beyond neurochaetae tips. Nephridial papillae short, starting at chaetiger 6 (Fig. 5). Pygidium short, with one pair of long anal cirri.



Figures 2–7. (2) *Benhamypolynoe* cf. *antipathicola* on the branches of *Stylopathes adinocrada*: (3) median chaetigers of *B. antipathicola* showing elytrophores, elytra and dorsal cirri; (4) head of *B. antipathicola* showing the prostomium, palps and antennae; (5) posterior chaetigers of *B. antipathicola* showing the ventral cirrus and neuropodia; (6) neurochaetae from posterior chaetigers, showing a faint serration; (7) detail of distal tip of neurochaetae. (ch) chaetae, (dc) dorsal cirrus, (el) elytra, (et) elytrophore, (ct) cirratophore, (la) lateral antennae; (ma) median antennae, (ne) neuropodium, (pa) parapodium, (pl) palp, (pr) prostomium, (tc) tentacular cirrus. Scale bars: 2–4: 1 mm, 5 = 200 µm, 6 = 100 µm, 7 = 10 µm.

Material examined. A complete specimen with 136 chaetigerous segments, with 103 mm in length, and 4 mm wide. MOUFPE-CNI 113; 04°47'50"S; 036°11'01"W (Potiguar Basin), 423–461 m depth (1 specimen).

Distribution. Pacific: Off New Zealand, 128 m depth (Benham 1927), Queensland, Australia, 398 m depth (Pettibone 1989), off New Caledonia and adjacent waters, French Polynesia, Wallis and Futuna, Solomon Islands, Indonesia, and Madagascar, from 300–600 m depth (Molodtsova and Budaeva 2007), Malay Archipelago; Atlantic: off Key West, Florida, 237 m depth (Pettibone 1970) and Northeastern Brazil, 423–461 m depth (present study), first report for the Southwestern Atlantic.

Remarks. *Benhamipolynoe antipaticola* was originally described as *Lapidasthenia antipaticola* Benham, 1927, from 128 m depth off New Zealand, in association with *Stylopathes tenuispina* (Silberfeld, 1909) (= *Parantipathes tenuispina*) (Opresko 2006). The morphological features of the Brazilian specimens agree with the original description, except in the absence of pigmentation in the holotype, according to Pettibone (1989).

Ecology. Found in association with *Stylopathes adinocrada* Opresko, 2006, a new host for this species. It is also known to live in association with *Stylopathes columnaris* (Duchassaing, 1870) (Pettibone 1970, Britayev et al. 2014).

Host black coral

Stylopathidae Opresko, 2006

Stylopathes adinocrada (Opresko, 2006)

Figs 8–10

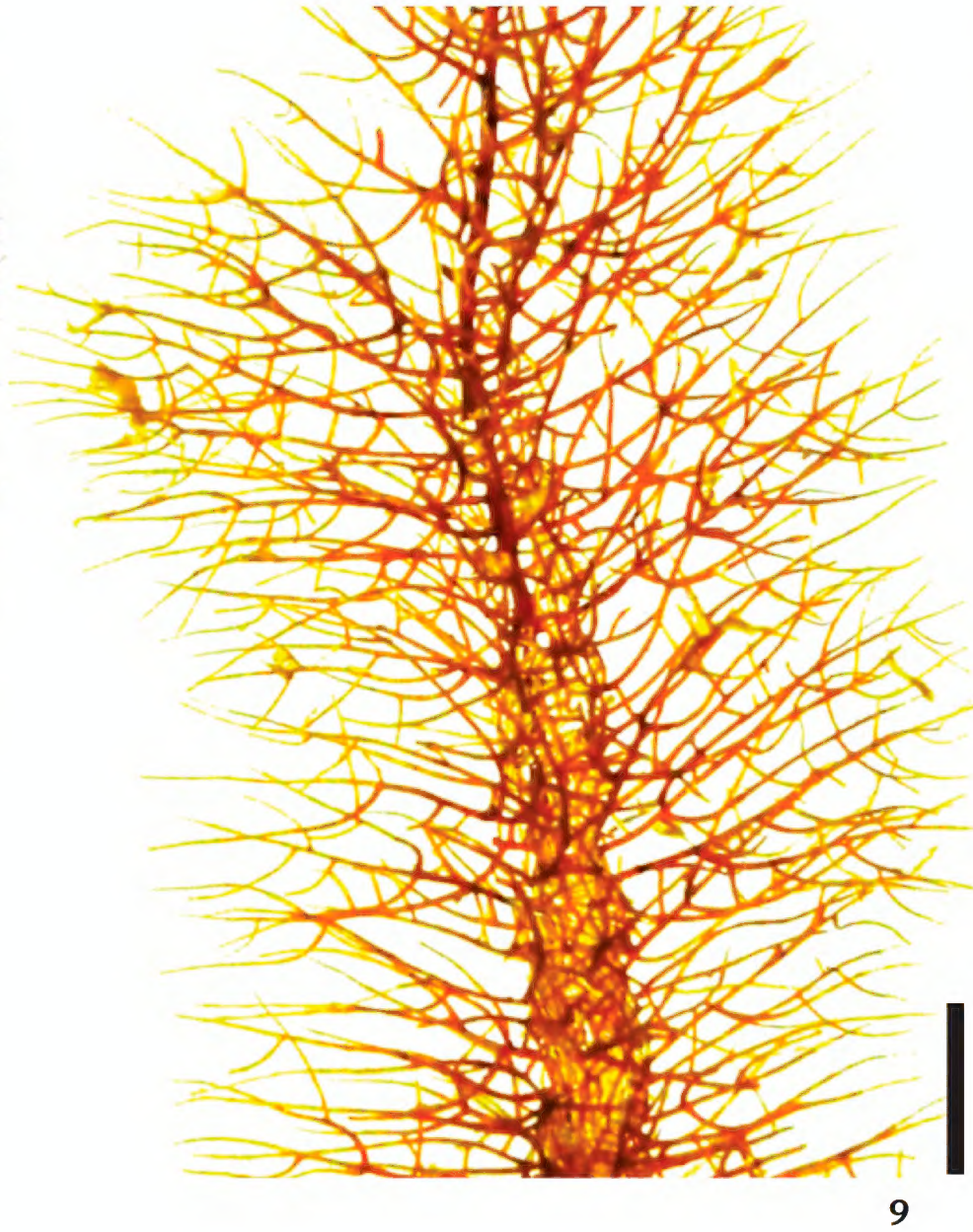
Antipathes columnaris; Opresko, 1974: 101–115 (part).

Stylopathes adinocrada Opresko, 2006: 123.

Description. Colony highly pinnulated, monopodial, 19.5 cm long, with a central formation of fused pinnules forming a "worm run" harboring a polychaete (Figs 8–9). Primary pinnules with subpinnulation and a dense pinnulation pattern, arranged in three rows, 10–20 mm long, with ca. 11 secondary pinnules per posterior primary one. Colonies pinnulated to fourth order. Subpinnules slightly more abundant on abpolypar side of posterior primary pinnules; proximal end of primary pinnules with denser pinnulation pattern. Spines small, 0.024 to 0.06 mm long, arranged in ca. 5 rows in lateral view (Fig. 10), separated ca. 0.28 mm each other within same row. Polyps not seen (lost tissue).

Material examined. MOUFPE-CNI 113; 04°47'50"S; 036°11'01"W (Potiguar Basin), 423–461 m depth (1 colony).

Distribution. Bahamas, 134–708 m depth (Opresko 2006), Surinam (Opresko 2006) and northeastern Brazil (423–461 m



Figures 8–10. (8) Corallum morphology of *Stylopathes adinocrada*; (9) pinnulation pattern of *S. adinocrada*, showing the "worm run"; (10) organization of spines in *S. adinocrada*. Scale bars: 8–9 = 10 mm, 10: 100 µm.

depth, present study). *Stylopathes* (as *S. columnaris*) was known to occur in the coast of the state of Pará (Opresko 1974, Castro et al. 2006, Opresko 2006), but this is the first record of *S. adinocrada* for the Southwestern Atlantic.

Remarks. The studied material resemble the holotype, but was slightly larger, ca. 20 cm versus, ca. 17 cm, respectively. The pinnulation pattern was also similar but the spines were slightly smaller (up to 0.048 mm, rarely 0.06 mm) and more separated within a given row (i.e., up to 0.28 mm versus 0.1–0.2 mm the holotype). The type species of *Stylopathes* is *S. columnaris*, but two more species were included within the genus based on two morphotypes erroneously identified as *S. columnaris* (Opresko 2006). One of them, *S. adinocrada*, differs from *S. columnaris* mainly due to its scattered pinnulation pattern, although in both species the subpinules occur mainly in the distal portion of the primary pinnule, rarely covering the worm run (Opresko 2006).

Paraholoplepidella cf. *greeffi* and *Tanacetipathes* spp.

Symbiotic scale-worm

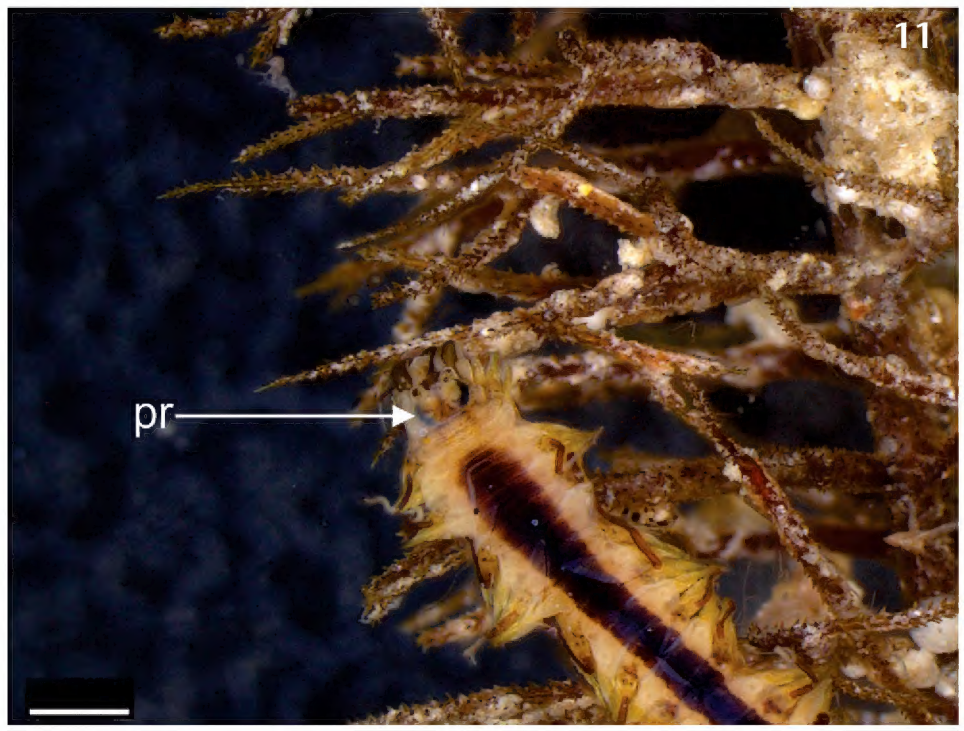
Polynoidae Kinberg, 1856

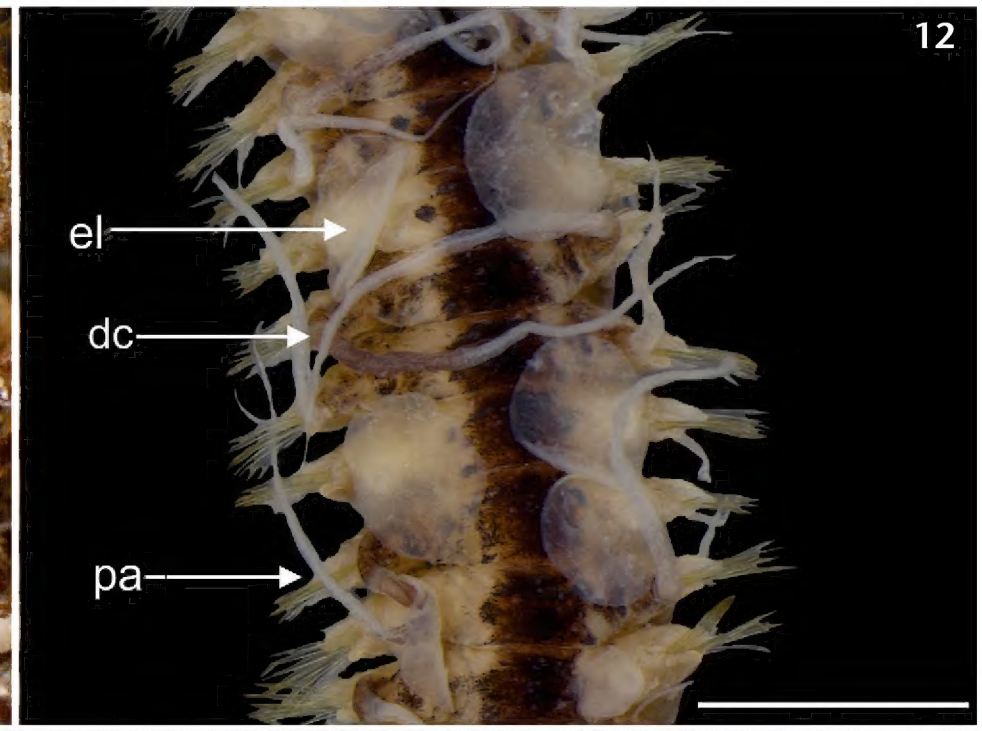
Paraholoplepidella Pettibone, 1969

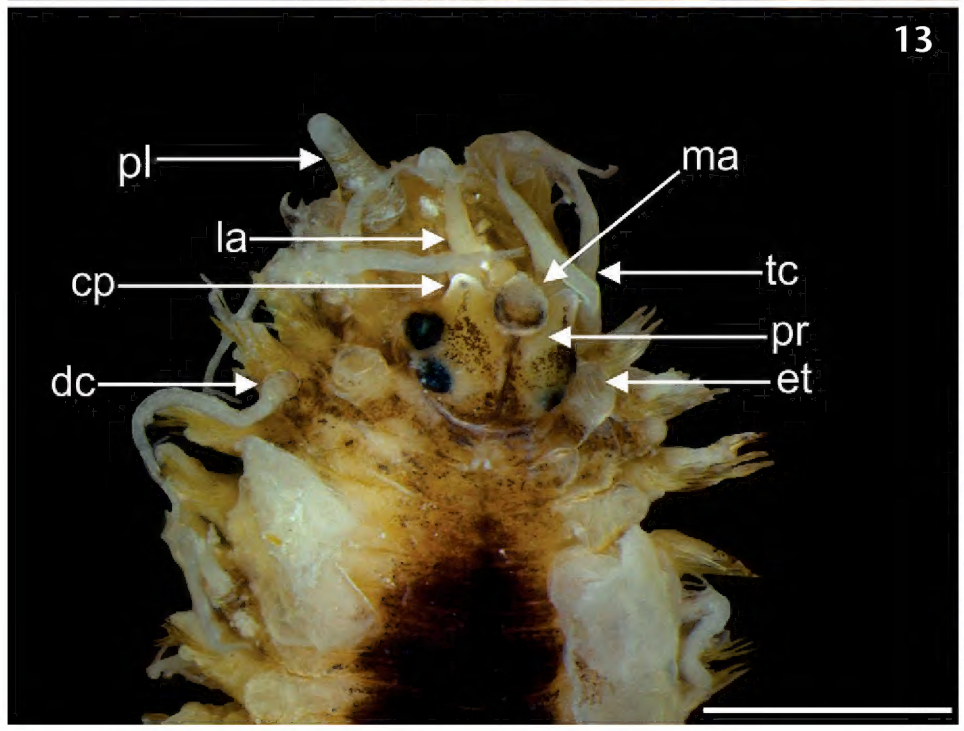
Paraholoplepidella cf. *greeffi* (Augener, 1918)

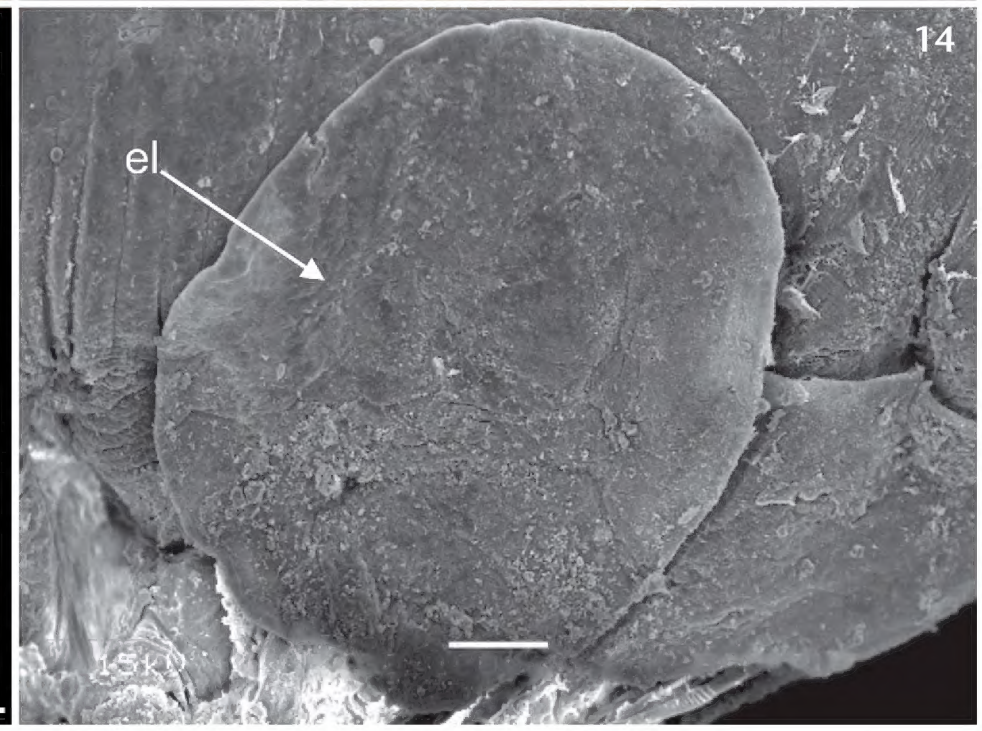
Hololepidella greeffi Augener, 1918: 148, pl. 2, figs 22–24, pl. 3, fig. 52, text-fig. 9.
Hololepidella fagei Rullier, 1964: 132, fig. 4.

Diagnosis. Body dorsoventrally flattened, elongate, with up to 140 segments (Figs 11–12). Elytra very small, leaving mid-dorsum and parapodia uncovered. Fifty or more pairs of elytra on elytrophores of segments 2, 4, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 26, 29, 32, alternating on posterior segments. Prostomium bilobed, with distinct cephalic peaks, and two pairs of large eyes.









Figures 11–14. (11) *Paraholoplepidella* cf. *greeffi* on the branches of *Tanacetipathes tanacetum*; (12) median chaetigers of *P. greeffi* showing elytra and dorsal cirri; (13) head of *P. greeffi* showing the prostomium, palps and antennae; (14) elytrae from posterior chaetigers of *P. cf. greeffi* showing a smooth edge. (cp) Cephalic peak, (dc) dorsal cirrus, (el) elytra, (et) elythophore, (la) lateral antennae, (ma) median antennae, (pa) parapodium, (pl) palp, (pr) prostomium, (tc) tentacular cirrus. Scale bars: 11–13 = 1 mm, 14 = 100 µm.

Ceratophores of median antenna in anterior notch, smooth, tapering, longer than palps. Lateral antennae inserted ventrally to median antenna, smooth, tapering (Fig. 13). Dorsal cirri smooth, with cylindrical long cirrophores (Fig. 15). Parapodia sub-biramous. Notopodia small, digitiform. Neuropodia with longer rounded prechaetal lobe, with subacicular digitiform acicular lobe. Notopodia with reduced number 0–5 notochaetae, unidentate, with faint serration blade (Figs 16–17). Neuropodia with 16–17 notochaetae, unidentate, with faint serration (Fig. 18). Pygidium conical, with two long cirri.

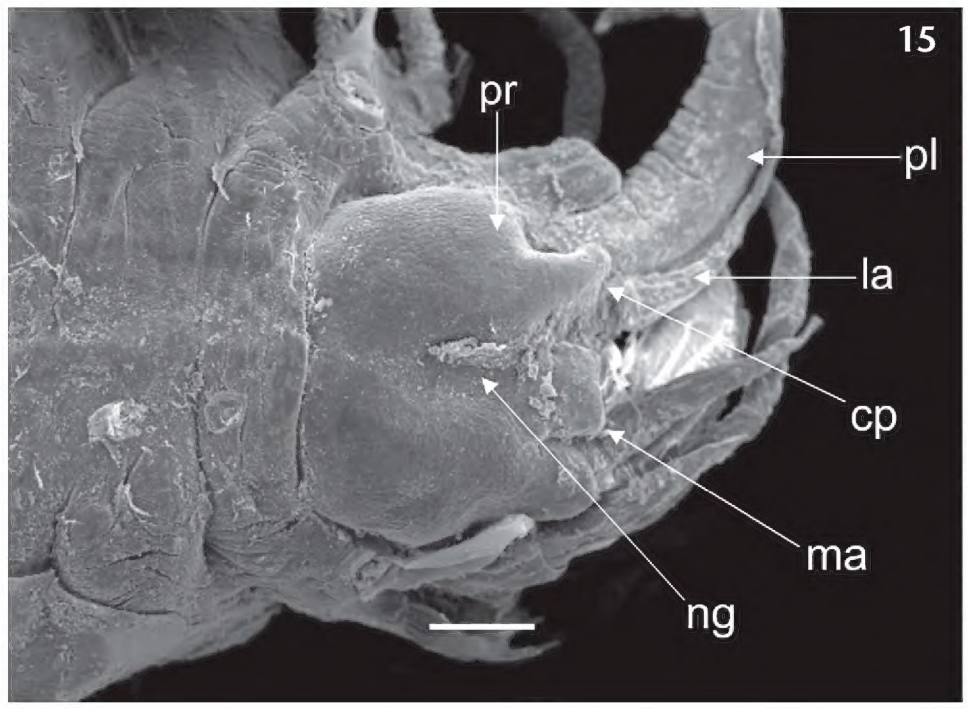
For complete description, see Britayev et al. (2014).

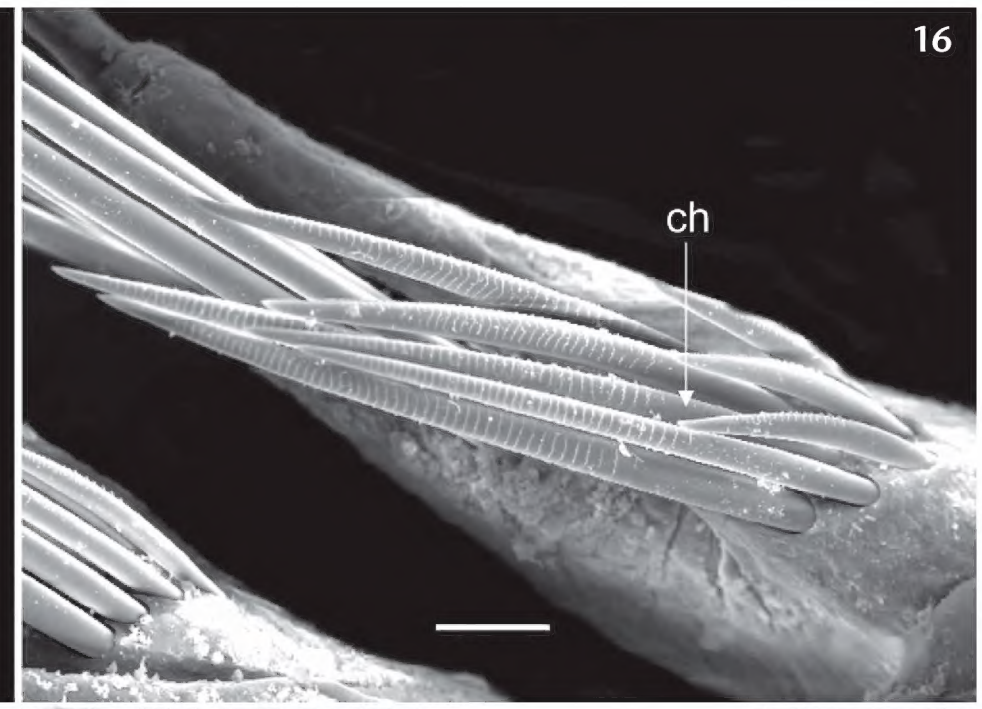
Variability. Our complete specimens varied in number of segments and elytra after chaetiger 23: specimen 1 (33 mm in length, 72 chaetigers, and 44 pairs of elytra), specimen 2 (44 mm in length, 128 chaetigers, and 70 pairs of elytra), specimen 3 (35 mm in length, 68 chaetigers, and 30 pairs of elytra) and specimen 4 (33 mm in length, 65 chaetigers, and 32 pairs of elytra. Our specimens have elytra on posterior most chaetigers.

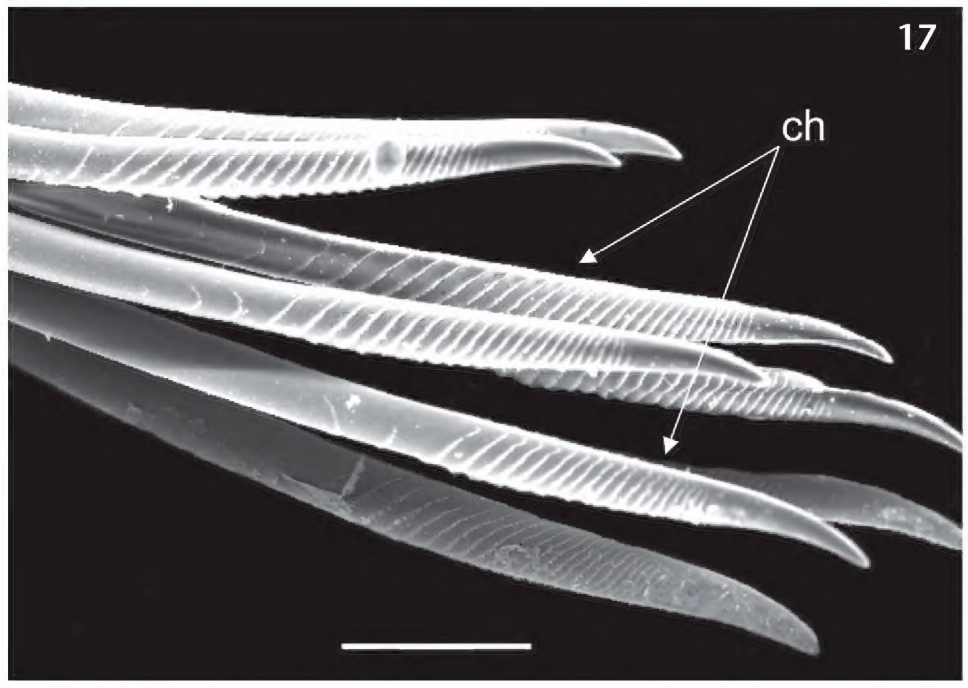
Material examined. Two complete specimens, four anterior, and three posterior (i.e., mid-posterior body end) fragments, found on the branches of *T. barbadensis*. MOUFPE-CNI 351, 04°44″31′S, 36°26′19″W, 101–108 m depth (1 specimen from *T. tanacetum*); MOUFPE-CNI 350, same collection data (2 specimens from *T. thamnea*). MOUFPE-CNI 349 (same collection data 1 specimens from *T. barbadensis*).

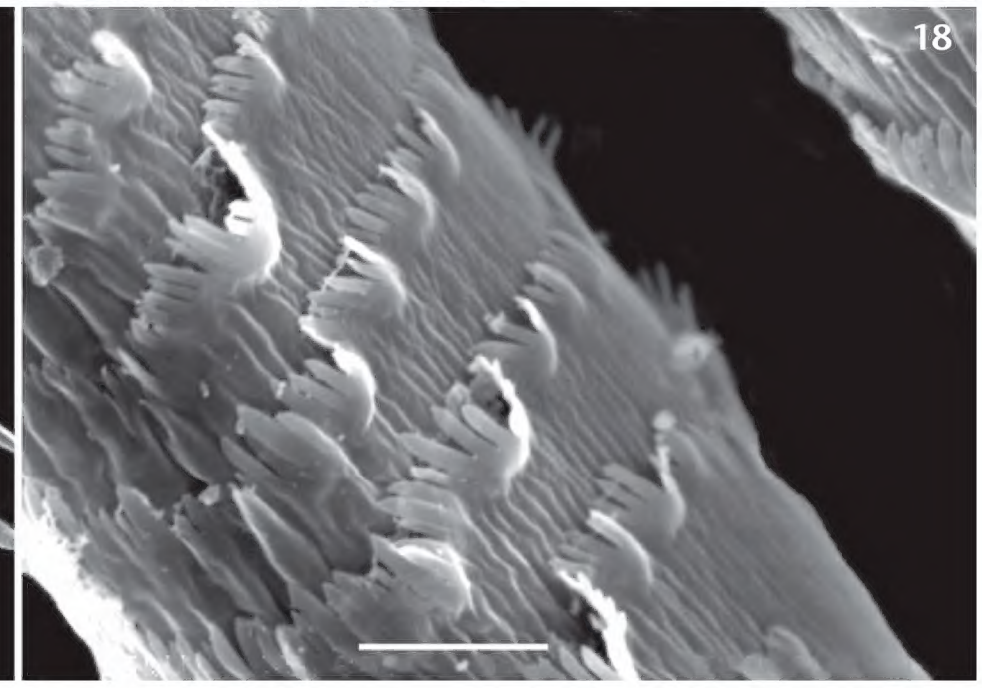
Distribution. Tropical and Equatorial East Atlantic, Cabo Verde and São Tomé Archipelagos; Western Atlantic Brazil (this paper).

Remarks. *Paraholoplepidella greeffi* was originally described as *Hololepidella greeffi* Augener, 1918, as free-living from shallow









Figures 15–18. (15) Head of *P. cf. greeffi* showing the prostomium and their structures; (16) Parapodia of *P. cf. greeffi* showing notochaetae and neurochaetae; (17) Neurochaetae from median chaetigers of *P. cf. greeffi*; (18) Detail of distal tip of neurochaetae. (ch) Chaetae, (cp) cephalic peak, (la) lateral antennae, (ma) median antennae, (ng) nuchal groove, (pl) palp, (pr) prostomium. Scale bars: 15 = 1 mm, 16–17 = 100 µm, 18 = 10 µm.

waters off São Tomé and Cabo Verde Islands (West Africa). Posteriorly, Pettibone (1969) proposed *Parahololepidella* to include *Hololepidella*. The morphological features and cryptic color in preserved specimens from Brazil mostly agree with the currently known descriptions (Augener 1918, Hartman 1959, Pettibone 1969), including the most recent redescription (Britayev et al. 2014), but elytra are present till the end of the body.

Ecology. *Parahololepidella* cf. *greeffi* was first reported as a symbiont by Britayev et al. (2014), living in association with *Tanacetipathes* cf. *spinescens* (Gray, 1857) (= *Antipathes spinescens*) (Opresko 2001). Our results confirm the commensal character of the species, which appears to be a polyxenous black coral symbiont as, in addition to *T.* cf. *spinescens* it also lives in association *T. tanacetum*, *T. barbadensis* and *T. thamnea*. *Tanacetipathes tanacetum* has also been found too harbor *Antipathipolyeunoa nuttingi* Pettibone, 1991 for in North Atlantic Ocean and Caribbean Sea (i.e., Barbados) locations (Pettibone 1991, Molodtsova and Budaeva 2007).

Host black corals

Myriopathidae Opresko, 2001

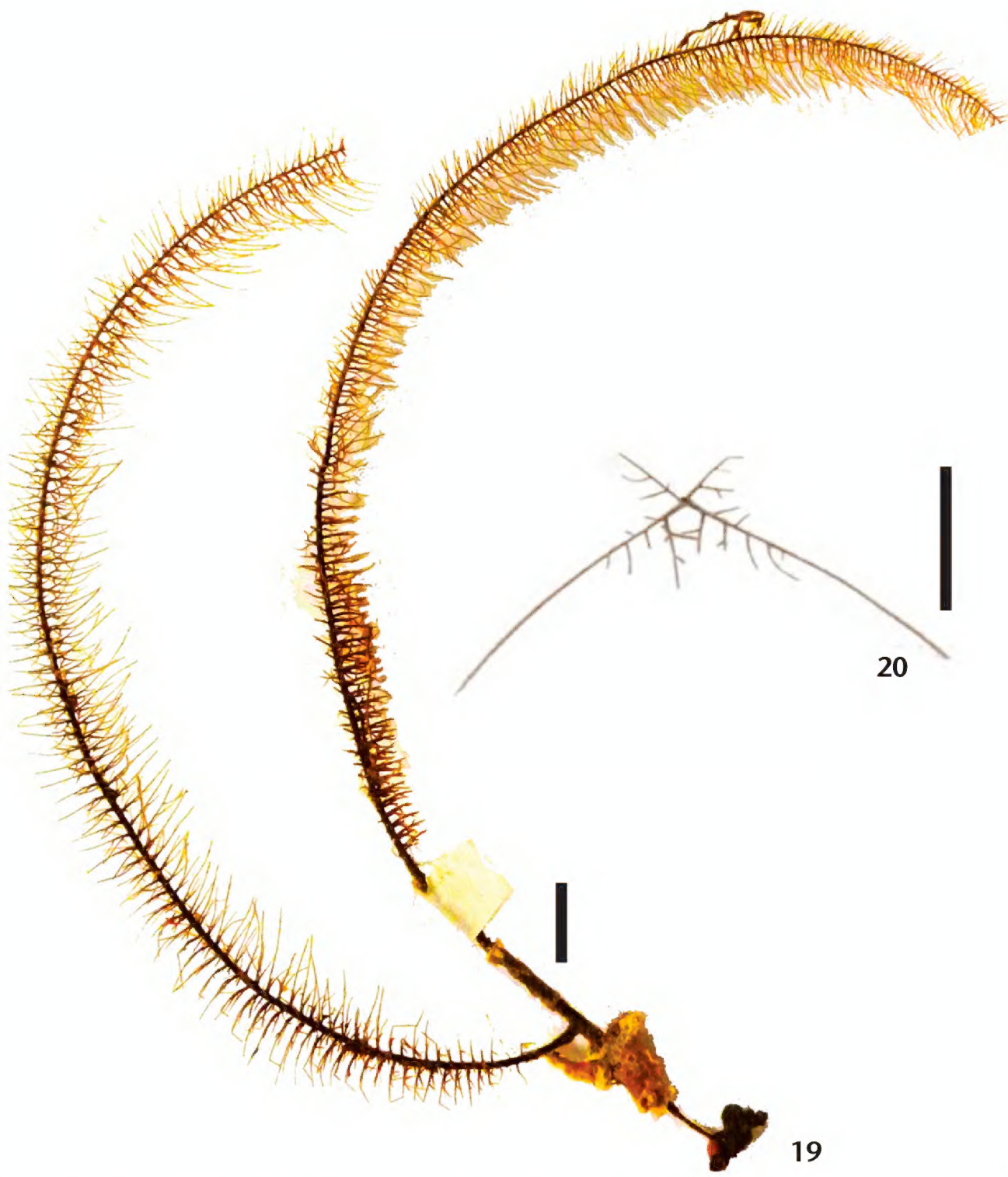
Tanacetipathes Opresko, 2001

Tanacetipathes tanacetum (Pourtalès, 1880)

Figs 19–21

Antipathes tanacetum Pourtalès, 1880: 116, pl. 3, fig. 13.

Description. Corallum monopodial, with branches rarely up to 2nd order, in bottlebrush pattern, and primary pinnules usually in 4 main rows (Fig. 19). Primary posterior pinnules larger than primary anterior pinnules, 6–20 mm long, varying according to colony size. Anterior primary pinnules 5–7 mm long, cycle separated by ca. 1 mm. Angle between posterior and anterior primary pinnules (polypolar and abpolypar sides, respectively) of ca. 45°. Angle between two anterior or two posterior primary pinnules



Figures 19–21. (19) Corallum morphology of *Tanacetipathes tanacetum*; (20) cross section showing pinnules cycle of *T. tanacetum*; (21) organization of spines in *T. tanacetum*. Sacale bars: 19, 20 = 1 cm, 21 = 200 µm.

(polypar/polypar sides or abpolypar/abpolypar, respectively) of ca. 160°. Secondary pinnules scarce, 3 – 7 (more common 4 – 5), usually near proximal end of posterior primary pinnules (Fig. 20). Tertiary pinnule rarely present, usually 1 or 2 per secondary pinnule when present. Spines with few ornaments, conical (Fig. 21). Polypar spines 0.048–0.1 mm long, separated by 0.12–0.18 mm. Abpolypar spines 0.036–0.06 mm long. Polyps not seen (lost tissue).

Material examined. MOUFPE-CNI 351, 04°44"31'S; 36°26'19"W, 101–108 m (Potiguar Basin).

Distribution. Bermuda (Cairns et al. 1986), Gulf of Mexico, Potiguar Basin (present study) and southern coast of Brazil (Pérez et al. 2005, Opresko 2009) 50 to 108 m. This is the first record for the Potiguar Basin, northeast Brazil.

Remarks. The lectotype of *T. tanacetum* designated by Pérez et al. (2005) has posterior primary pinnules 1.2 cm long versus the 2 cm of the Potiguar Basin material, which also lack the characteristic curved back pinnules of the lectotype. Nevertheless, not all specimens have these pinnules (Pérez et al. 2005). Our specimens resemble those from off Bahia, northeastern Brazil, which had polypar spines 0.04–0.27 mm long (Loiola and Castro 2005), in agreement with the 0.13 to 0.3 mm reported by Opresko and Sanchez (2005). In contrast, our colonies showed polypar spines 0.048–0.1 mm long, similar to those of the specimens from Bahia (Loiola and Castro 2005). The original description emphasizes the presence of a "parasitic worm" similar to that occurring in *S. columnaris*, but which did not produced changes in host growth (Pourtalès 1880). The symbiotic worm was described as *Antipathipolyeunoa nuttingi* Pettibone, 1991 in a paper that also provided an identification key based primarily on the associated species of black corals.

Tanacetipathes barbadensis (Brook, 1889)

Figs 22–27

Aphanipathes barbadensis Brook, 1889: 128, pl. II, fig. 10; pl. XI, fig. 4.

Description. Corallum monopodial or branched up to the first order with branches emerging close to base (Fig. 22). Colonies in bottlebrush pattern, with primary pinnules mainly arranged in four rows, reaching up to 6 rows. Secondary pinnules inclined towards distal end of primary posterior pinnule; anterior primary pinnules rarely with subpinnulation. 1–4 (more commonly 2–3) long secondary pinnule per posterior primary, usually at proximal end of primary pinnule (Fig. 23). No more than three tertiary pinnules, when present, near proximal end of secondary pinnule. Posterior primary pinnules 10–26 mm long. Anterior primary pinnules 3–12 mm long. Secondary pinnules 2–12 mm long (more commonly 6 mm). Smooth, conical spines, arranged in 5 to 6 rows visible under optical microscope (Fig. 26). Polypar spines 0.084–0.216 mm long (more commonly 0.144 mm). Abpolypar spines 0.048–0.084 mm long. Distance between spines mostly 0.12–0.18 mm, with ca. four spines per mm in each row. Polyps not seen (lost tissue).

Material examined. MOUFPE-CNI 349, 04°44"31'S; 36°26' 19"W, 101–108 m (Potiguar Basin).

Distribution. Barbados (Brook 1889); Ship Mouth, NW Trinidad (Warner 1981); Gulf of México (Opresko 2009), Brazilian coast, from Potiguar Basin, RN (present study) to the Abrolhos Bank (Loiola and Castro 2005), 30 to 108 m depth.

Remarks. *Tanacetipathes barbadensis* ressembles *T. tanacetum* (Pourtalès, 1880), but differs in having three or less secondary pinnules per subsequent primary pinnule (instead of 3–7 in *T. tanacetum*). Our specimens show posterior pinnules smaller than those previously reported for the species, up to 30 mm long versus 60 mm in Opresko and Sanchez (2005), while agreeing with those described by Brook (1889) and Loiola and Castro (2005). The latter, also from the Brazilian continental shelf, presented posterior primary pinnules up to 45 mm long. Therefore, we suggest that the presence of small sized pinnules may be an intraspecific variation typical of Brazilian populations.

Tanacetipathes thamnea (Warner, 1981)

Figs 25–27

Antipathes thamnea Warner, 1981: 148–151, figs. 2–4.
Tanacetipathes paula Perez, Costa and Opresko, 2005: 8–12, figs 5–8.

Description. Colonies 8–25 cm long, in bottlebrush pattern, monopodial, with branches absent or branching to second order, near colony base (Fig. 25). Primary pinnules usually arranged in four rows. Primary posterior pinnules 10–18 mm long (more common 14–16 mm), larger than the anterior ones (3–12 mm long, varying in juvenile colonies). Secondary pinnules tipping toward distal end of primary pinnule. 7–20 (more commonly 10–15) secondary pinnules per posterior primary pinnule (Fig. 26), 2–12 mm long. Tertiary pinnules scarce, usually more abundant on abpolipar side of posterior primary pinnule, 1–4 per posterior secondary pinnule. Angle between posterior and anterior primary pinnule (polypar and abpolypar sides, respectively) 55°–70°. Angle between two anterior or two posterior primary pinnules (polypar/polypar sides or abpolypar/abpolypar, respectively) 115–130°. Abpolypar side of posterior primary pinnules with more secondary pinnules than polypar side. Spines smooth, with few ornaments, slightly inclined toward distal end of pinnule or branch (Fig. 27). Distance between spines mainly 0.12–0.18 mm. Polypar spines 0.1–0.2 mm long; Abpolypar spines 0.036–0.084 mm long. Polyps not seen (lost tissue).

Material examined. MOUFPE-CNI 350, 04°44"31'S; 36°26' 19"W, 101–108 m (Potiguar Basin).

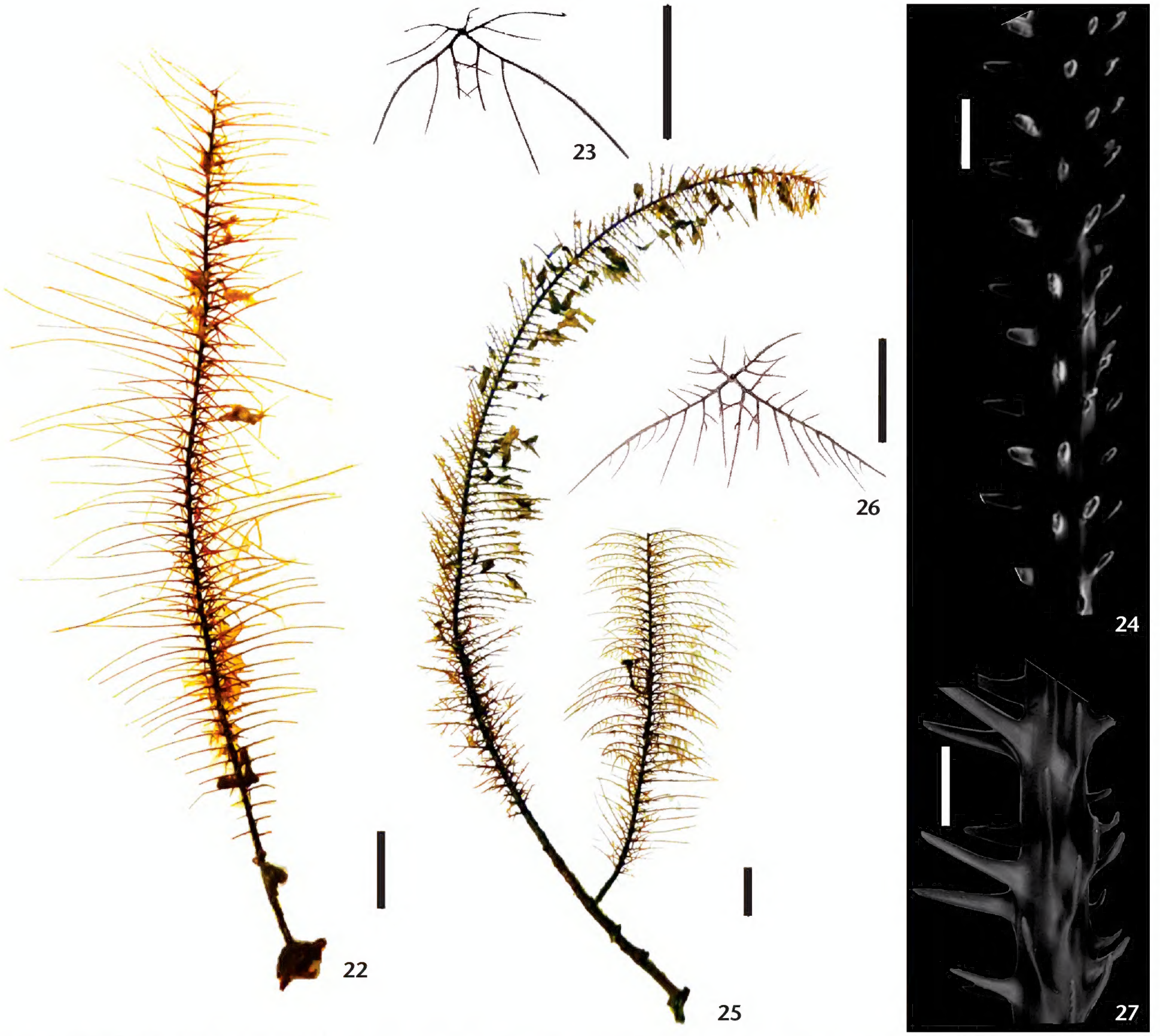
Distribution. Boca de Navios, NW Trinidad (Warner 1981), Gulf of México (Opresko 2009), and Brazilian coast (Loiola and Castro 2005, present study), 30 to 108 m depth. This is the first record of the species for the Potiguar Basin, Brazil.

Remarks. Our specimens differ from the syntype described by Warner (1981) in some characters. They were slightly shorter (up to 25 cm long versus 20–40 cm long). Some colonies had posterior primary pinnules more elongated and with more secondary pinnules than that described by Loiola and Castro (2005). Warner (1981) also noted that there may be 5–10 secondary pinnules per posterior primary in a10 mm primary pinnule, considering that a pinnule may reach up to 25 mm. Moreover, Loiola and Castro (2005) found 1–2 tertiary posterior pinnules per posterior secondary whereas our specimens had 1–4. Also, Warner (1981) mentioned a few distally inclined tertiary pinnules. Outnumber primary pinnules may occur especially in the more distal regions of the colonies as well as in larger colonies. Warner (1981) mentioned the presence of errant polychaetes in almost all colonies, living in a kind of tube formed by pinnules on the side of the colony turned toward the sea current.

DISCUSSION

Many authors have reported symbiotic relationships involving black corals since the 19th century, although most records were observations limited to strictly taxonomic papers (Brook 1889, Van Pesch 1914, Pourtalès 1874) and the symbiotic polychaetes, especially the Polynoidae, were not an exception (Beneden 1869, Paris 1955, Britayev 1989, Martin and Britayev 1998). The paucity of ecological information was strongly related to the difficultness of conducting observational studies in deep seas, but also to the low number of taxonomists with expertise in Antipatharia (Cairns 2007).

Black corals are key-species in deep-sea habitats, from sheltering quirky communities of microorganisms to nesting centers for several fish species (Tazioli et al. 2007, Wagner et al. 2012). Some decapod crustaceans, for example, house on black coral colonies to acquire a better position in the water column for filter-feeding (Wagner et al. 2012).



Figures 22–27. (22) Corallum morphology of *Tanacetipathes barbadensis*; (23) cross section showing pinnules cycle of *T. barbadensis*; (24) organization of spines in *T. barbadensis*; (25) corallum morphology of *Tanacetipathes thamnea*; (26) cross section showing pinnules cycle of *T. thamnea*; (27) organization of spines in *T. thamnea*. Scale bars: 22, 23, 25, 26 = 1 cm, 24 = 200 µm, 27 = 150 µm.

Molodtsova et al. (2016) listed around 19 black coral species hosting 14 species of symbiotic polychaetes worldwide, with the Polynoidae being the most diverse polychaete family associated with antipatharians, but also with gorgonians.

In many cases, the polychaetes associated with *Tanacetipathes* and *Stylopathes* changed the coral growth and caused modifications in specific morphological characters (Pettibone 1989, 1991, Molodtsova and Budaeva 2007, Wagner et al. 2012). Therefore, some taxonomically important morphological traits must be addressed with caution in antipatharians affected by symbiotic associations (Molodtsova and Budaeva 2007). The unbranched monopodial form in the examined colonies might be a physiological reaction of antipatharians to symbiotic polychaetes, as suggested by Molodtsova and Budaeva (2007).

In this study, most polychaetes associated with *Tanacetipathes* spp. were found on the main axis of the corallum, screwing on the secondary pinnules in the posterior side of black coral. In contrast, the polychaete associated with *S. adinocrada* was found inside a "worm run" formed by anastomosed secondary pinnules along the corallum main axis, typical of the genus.

Indo-Pacific and Northern Atlantic species of *Stylopathes* have been reported with *B. antipathicola* as obligatory commensals (Wagner et al. 2012). Although our data are insufficient to suggest coevolution, it is worth noting that the same relationship with *Stylopathes* seems to occur in two distinct ocean basins separated long ago. Since there is strong molecular evidence of vicariant speciation in deep-sea corals and polynoids between Pacific and Atlantic basins (e.g., Quattrini et al. 2013, Serpetti et al. 2017), the coevolution hypothesis deserves testing, particularly because the existence of cryptic diversity in *B. antipathicola* cannot be discarded. The morphological differences between specimens from the two basins seems to support the idea that they correspond to different taxa. However, more careful morphological studies based on new materials, in parallel with molecular studies, is certainly needed to clarify the situation of these populations living in association with deep-water corals.

We have recorded *Parahololepidella* cf. *greeffi* living as commensal with three species of *Tanacetipathes*: *T. thamnea*, *T. barbadensis* and *T. tanacetum*, which represents a new modification of the ecological status of the species, from free living to monoxenous symbiont in Britayev et al. (2014) to polyxenous symbiont according to our data. Our results also confirm that the worms did not cause drastic modifications to their hosts.

All 300 antipatharians from Myriopathidae and Antipathidae, collected in 75 Indo-Pacific stations showed symbiotic relationships with polynoid and eunicid polychaetes, including *B. antipathicola* forming latticed tunnels on *S. columnaris* (Molodtsova and Budaeva 2007). The tube was initially secreted by the polychaete and subsequently structured by anastomosis of pinules along the central axis of the colony. The same phenomenon was observed in our samples. Molodtsova and Budaeva (2007) also examined Caribbean samples of *Tanacetipathes* (*T. spinences*) with *P. greeffi* as symbiont of the colonies. In these case, corals also present anastomosed secondary pinules but, as in the Brazilian material, they did not form exactly a "worm run".

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